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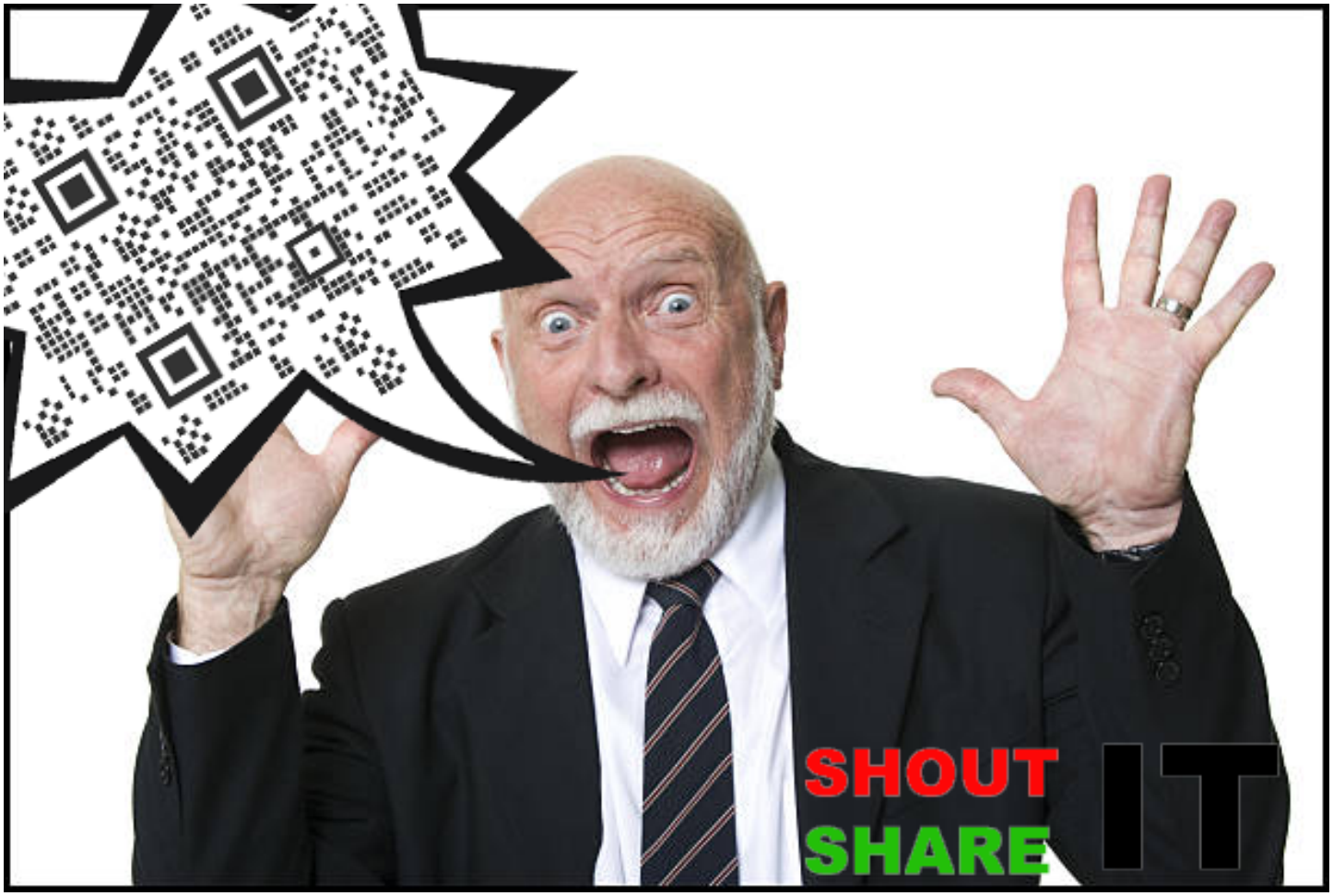
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One of the problems which has plagued the Poultry Industry throughout the years has been that of cannibalism. This is a vice wherein birds are attacked by their associates, resulting in partial injury and even death. Cannibalism may be manifested in several ways, including feather pulling and picking in various areas of the body.

The rapid expansion of the broiler industry, including the introduction of new breeds and crosses with Cornish blood in them, new feeding methods, such as pelleted feed, and mass production methods have made the problem of cannibalism a continuing serious one. Broiler growers are constantly faced with serious losses in income due to the lower price they receive when barebacked broilers are marketed. Several theories, including that of light intensity, have been developed as to the cause of cannibalism, but the actual cause is still unknown.

This study was initiated to investigate the following:

(1) The role which light intensity and length of light period might play in producing cannibalism in broilers.

(2) Whether light intensity, combined with form of feed and/or floor space allotment, causes an interaction resulting in cannibalism in broilers.

(3) The effect of light on other factors besides cannibalism, including body weight, feed conversion, mortality rate and uniformity of weight in broilers.

Clark (1953) listed the following as possible causes for cannibalism: nutritional deficiencies, such as low protein, low fiber content of ration and lack of salt; faulty management such as high temperature in the brooder house, lack of fresh air, crowding, insufficient feeding and watering space and excessive light. Kennard and Chamberlain (1944) found that when pullets consumed too much whole grain and too little mash with its high protein, mineral, and vitamin ingredients that feather picking followed by cannibalism would result.

This publication includes portions of a thesis submitted to the Graduate School in partial fulfillment of the requirements for the Doctor of Philosophy degree in the Department of Poultry Husbandry at the Pennsylvania State University, University Park, Pennsylvania. This investigation is part of the New Hampshire contribution to The NE-8 "Essentials of Poultry Housing for the Northeast", regional project.

Genetic factors may contribute to the incidence of cannibalism. Weaver and Bird (1934) stated that the light breeds of the Mediterranean class were much more susceptible to the vices of cannibalism than the heavier breeds of the American and Asiatic classes. In an unpublished summary of three year's results in the New Hampshire Broiler Test, it was found by the author that crosses containing Cornish blood were more prone to cannibalism than were most of the pure breeds.

Studies in respect to light intensity are limited in the literature. Most of them are concerned with reproductive activity rather than the factors considered in this study. However, the possible relationship between reproductive activity and feather picking should not be overlooked. Bissonnette (1931) found that light from bulbs varying in strength from 10 to 60 watts was capable of inducing progressive testis changes in starlings. However, the effects produced were not of the same magnitude and the rate of acceleration of germinal activity was not the same with different intensities of added light. Burger (1939) in studies with light intensities in wild birds concluded that gradually increased light intensity, when the light was administered over day-lengths which in themselves did not produce spermatogenesis, were incapable of testicular stimulation. Nicholas and co-workers (1941) studying light intensities ranging from 0.5 to 38.0 foot candles at a central point in the working area, and from 0 to 27.0 at a central point on the roosting perches in laying hens, found that intensity had no effect on the degree of reproductive response. Shutze and co-workers (1960) found that growth rate in broilers was the same at light intensities of 1 or 3 foot candles.

Clegg and Sanford (1951) exposed chickens to alternate six-hour periods of light and darkness and found that they were 66 grams heavier at six weeks of age than chickens exposed to alternate periods of 12 hours of light and darkness. When the periods were only two hours in length, the weight differences were even greater. They suggested that the shorter intervals of light and darkness prevented the chickens from taking excessive exercise; therefore, the nutrients were used for growth rather than being dissipated. Lamoreux (1943) found that the gains in the body weight of domestic fowl were greatest when the daily period of light was inadequate for the maximum stimulation of reproduction. Moore (1957) grew broiler type birds from one day to eight weeks with exposures of 6, 12, 18 and 24 hours of total light per day. The results indicated that up to 3 or 4 weeks of age the chicks grew faster with continuous light and that less light was needed as they neared 8 weeks. Better growth also was obtained when light was applied in 4 or 6 periods per day instead of 1 period. Shutze and co-workers (1960) also found that body weight gain of birds exposed to continuous incandescent light was markedly superior to that of birds exposed to other lighting regimes.

In respect to the influence of light upon feathering condition, Moultrie and co-workers (1954) found that chicks reared from 6 to 10 or from 6 to 12 weeks of age under continuous light had fewer undesirable body feathers than birds reared during that time under 5, 10, or 15 hours of daily light. Moultrie and co-workers (1955) found a relative absence of pinfeathers at 24 weeks of age in turkeys restricted to 10 hours of light daily compared to those receiving 24 hours of light daily.

Experimental work concerned with the interaction effect of light intensity and such factors as floor space or form of feed is extremely limited.

However, numerous studies have been conducted concerning these individual factors. Tomhave and Seegar (1945), Hartung (1955), Brooks and co-workers (1957) all found that as the amount of floor space per bird increased the average weight per bird also increased. Most experiments conducted on pelleted versus mash feeding indicated a weight advantage in favor of pellet fed birds. Lanson and Smyth (1955) found that both weight gain and feed conversion were improved with pellet feeding. Lonsdale and co-workers (1957) found that feeding a pelleted ration resulted in a significantly heavier chicken, but that feed conversion was not improved and that the pellet diet increased feather picking.

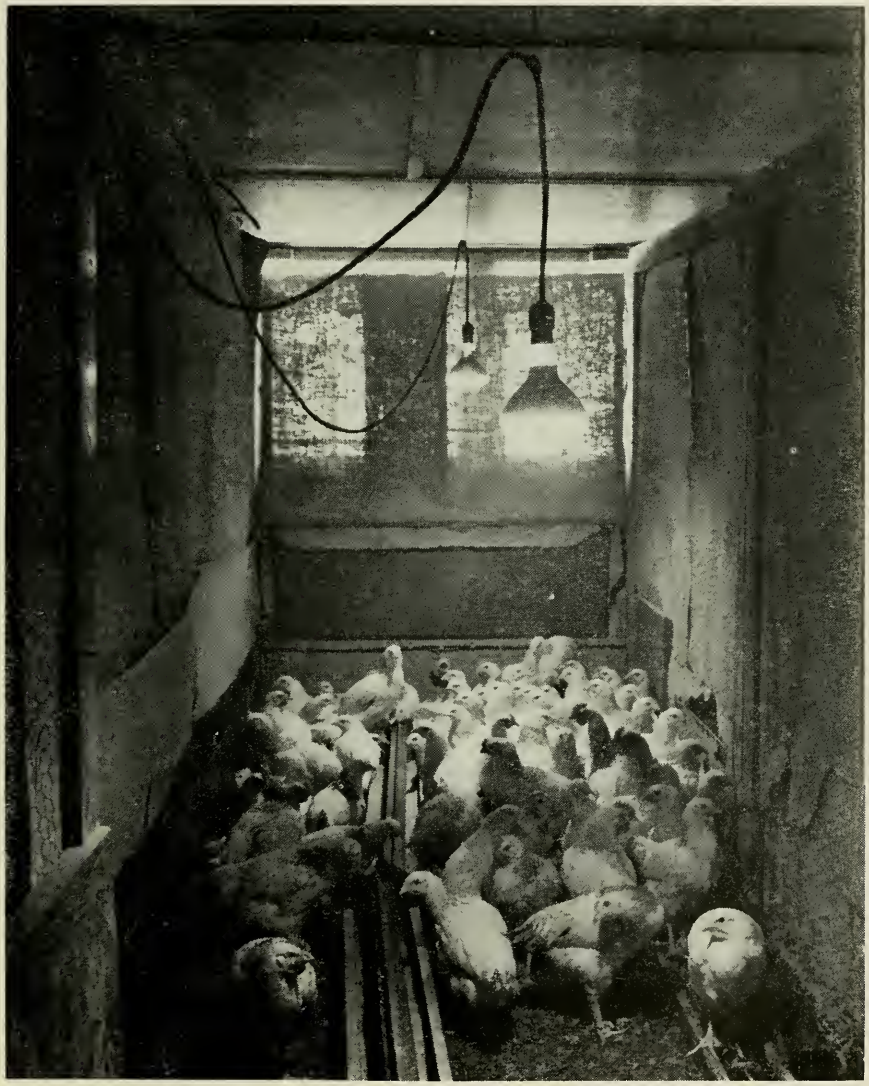

Figure 1. A typical pen arrangement showing burlap baffle, covered partitions and light arrangement.

PROCEDURE OF THE INVESTIGATION

Facilities

The Broiler Test Building, a modern conventionally designed broiler house situated on the University of New Hampshire Poultry Farm, was used for conducting all trials. One wing on the second floor of the building was divided into 40 pens each 4′ x 15′ in size.

Heat was provided by a hot water system with fin-type radiation along the outside wall. The wire partitions between pens were covered with a light tan colored sisal kraft building paper and a 12″ Masonite panel at the bottom. All windows were covered with a baffle of burlap located so

Figure 2. Method of obtaining light intensity readings with Weston Illuminator Meter.

as to exclude a large percentage of the light rays, but still provide for ventilation. Two reflector-type floodlight bulbs of either 75, 150 or 300 watts were used in each pen to provide light. The wattage and height of the bulb from the floor enabled the various foot candle intensities to be maintained. The two bulbs were located on a line equidistant from each side wall and one third of the distance from the front and rear of each pen. Feeding space per chick of 1″ for day old to 2 weeks, 2″ to 6 weeks and 3″ to completion was provided by using hoppers of 3 different sizes. A one gallon glass waterer was used for the first two weeks in each pen. This was replaced with a three foot trough and a Fox-type valve providing a continuous supply of water.

Stock for every experiment was purchased from a large breeder hatchery, which was in position to help us obtain stock with similar breeding for all trials. The bird used was a crossbred, widely used in the broiler industry, with Cornish blood on the male side.

New England College Conference Rations were used throughout the experiment. Only slight modifications were made in these formulae from year to year.

Measurement of Light Intensity

A Weston Illuminator Meter — Model 756, with Viscor filter — was used to determine the foot candles. This instrument indicates the illumination in foot candles based on the New Candle, on the surface of the light target, or lumens, per square foot evenly distributed. The target was placed on a piece of 2″ x 4″ lumber on edge beside the feeder.

Outline of Experiments

The study was divided into two parts. The purpose of the first part was to determine the influence of light intensity and daily light dosage on feather condition, body weight, feed conversion, and mortality rate in broilers at 10 weeks of age.

The purpose of the second part was to determine the effect of the feed form and floor space allotment in combination with high and low light intensity on feather condition, body weight, feed conversion and mortality rate in broilers at 10 weeks of age.

In the first part, three levels of light intensity and two of daily dosage of light were used. The two dosages of light were 12 and 24 hours, and the levels of light intensity were 15, 60, 120 foot candles. The layout of each experiment followed a randomized block design. Each treatment combination was replicated three times. A 2 x 3 factorial analysis was used. In two out of the three experiments a natural daylight pen was added to each replicate. Chicks were randomized from the shipping boxes to each pen so that each pen received an equal number of chicks from each box. Thirty male and thirty female day old chicks were placed in each pen.

The dates for the three experiments in Part 1 were as follows:

Experiment I — August 23, 1956, to November 1, 1956

Experiment II — May 17, 1957, to July 26, 1957

Experiment III — February 10, 1958, to April 21, 1958

The following data were obtained:

1. Individual weight at 10 weeks of age.
2. Individual feather score at 10 weeks of age (based on

one for complete feathering on back, *two* for ¼ to ½ of feathers missing from back, *three* for ½ to ¾ of feathers missing, and *four* for a complete bare-backed bird.

3. Feed consumption and feed conversion.
4. Daily mortality.

In the second part of the experiment, two forms of feed (mash and pellets) and two floor space allotments (one square foot per bird and two-thirds square foot per bird) were combined with both 15 and 120 foot-candles of light. All groups received 12 hours of light daily. Thirty or forty-five day-old chicks of each sex were placed in each pen depending on floor space allotment. All the chicks were randomized prior to pen distribution. The layout of each experiment again followed a randomized block design. There were two replicates for each treatment combination. A 2 x 3 factorial type analysis was used.

The dates for the three Experiments in Part 2 were as follows:

Experiment IV — November 20, 1956, to January 29, 1957

Experiment V — February 15, 1957, to April 26, 1957

Experiment VI — November 18, 1957, to January 28, 1958

Similar data as listed under Part I was obtained.

Table 1. The Effect of Light Intensity and Daily Light Dosage Upon Weight at 10 Weeks of Age.

Light Dosage	12 hours			24 hours			Natural Light
Light Intensity (foot candles)	15	60	120	15	60	120	
Experiments and Replicates	Average Weight in Pounds						
Experiment I							
Replicate 1	3.33	3.26	3.26	3.29	3.24	3.21	
Replicate 2	3.40	3.37	3.38	3.28	3.30	3.31	
Replicate 3	3.31	3.31	3.39	3.24	3.30	3.18	
Average	3.35	3.31	3.34	3.27	3.28	3.23	
Experiment II							
Replicate 1	3.26	3.15	3.23	3.41	3.35	3.28	3.33
Replicate 2	3.22	3.19	3.17	3.32	3.27	3.15	3.40
Replicate 3	3.24	3.34	3.14	3.36	3.26	3.14	3.16
Average	3.24	3.23	3.18	3.36	3.29	3.19	3.30
Experiment III							
Replicate 1	3.27	3.20	3.21	3.26	3.19	3.22	3.32
Replicate 2	3.21	3.21	3.26	3.27	3.18	3.29	3.30
Replicate 3	3.32	3.22	3.22	3.33	3.12	3.20	3.27
Average	3.27	3.21	3.23	3.29	3.16	3.24	3.30
Average of 3 Experiments	3.29	3.25	3.25	3.31	3.24	3.22	3.30*

* Two experiments only

Light Dosage Average: 12 Hours 3.26; 24 Hours 3.26

Intensity Average: 15 foot candles 3.30; 60 foot candles 3.25; 120 foot candles 3.24

RESULTS OF THE INVESTIGATIONS

Part I — Light Intensity and Daily Light Dosage

Two daily light dosages of 12 and 24 hours were compared, as well as light intensities of 15, 60 and 120 foot candles. In two of the three experiments, a group with natural light was added in order to compare the controlled artificially lighted groups with natural light.

Effect Upon Body Weight

Table 1 gives the average 10 week body weight based on an equal number of each sex for three replicates in each experiment, the average for each of the three experiments, and finally the average of the three experiments. Based on the average of the three experiments the heaviest birds were the 24 hours, 15 foot candles group with an average of 3.31 pounds; followed closely by the natural light group with 3.30 pounds. The lightest were the 24 hours, 120 foot candles group with 3.22 pounds. The differences between the 12 and 24 hour dosages were extremely small, ranging from .02 pounds for the 15 foot candles; .01 pounds for the 60 foot candles; .03 pounds for the 120 foot candles; with the 12 hour dosage being the heaviest in all cases.

Table 2. The Effect of Light Intensity and Daily Light Dosage Upon Feed Conversion to 10 Weeks of Age.

Light Dosage	12 hours			24 hours			Natural Light
Light Intensity (foot candles)	15	60	120	15	60	120	
Experiments and Replicates	Pounds Feed Required to Produce a Pound of Gain						
Experiment I							
Replicate 1	2.76	2.68	2.68	2.76	2.68	2.66	
Replicate 2	2.69	2.72	2.74	2.73	2.73	2.69	
Replicate 3	2.72	2.60	2.69	2.74	2.68	2.71	
Average	2.72	2.67	2.70	2.74	2.70	2.69	
Experiment II							
Replicate 1	2.78	2.76	2.70	2.74	2.70	2.76	2.79
Replicate 2	2.84	2.75	2.68	2.86	2.81	2.89	2.79
Replicate 3	2.80	2.77	2.60	2.74	2.80	2.89	2.85
Average	2.81	2.76	2.73	2.78	2.77	2.85	2.81
Experiment III							
Replicate 1	2.35	2.35	2.39	2.42	2.39	2.46	2.34
Replicate 2	2.43	2.47	2.30	2.38	2.42	2.36	2.39
Replicate 3	2.41	2.30	2.40	2.41	2.41	2.36	2.39
Average	2.40	2.37	2.36	2.40	2.41	2.39	2.37
Average of 3 Experiments	2.64	2.60	2.60	2.64	2.63	2.64	2.59*

* Two Experiments only

Light Dosage Average: 12 Hours 2.61; 24 Hours 2.64

Intensity Average: 15 Foot Candles 2.64; 60 foot Candles 2.61; 120 Foot Candles 2.61

The summary of analyses of variance for the 10 week body weight for the combined average of the three experiments is given in Table 5. This indicates that the differences in body weight resulting from the various intensities and those resulting from dosages are both non-significant.

Effect Upon Feed Conversion

Table 2 presents the effect of light intensity and daily light dosage upon feed conversion to 10 weeks of age. Based on the average of the results from the three experiments the natural light group (two experiments only) had the best feed conversion, 2.59 pounds of feed required per pound of gain. The groups with the poorest feed conversion, 2.64 pounds, were the 15 foot candles with 12 hours, and the 15 and 120 foot candles with 24 hours.

The summary of analyses of variance for the 10 week feed conversion figures (Table 5) for the combined experiments indicates that the differences resulting from intensity and dosage were both non-significant.

Table 3. The Effect of Light Intensity and Daily Light Dosage Upon Per Cent Mortality to 10 Weeks of Age.

Light Dosage	12 hours			24 hours			Natural Light
Light Intensity (foot candles)	15	60	120	15	60	120	
Experiments and Replicates	Per Cent Mortality						
Experiment I							
Replicate 1	0.00	1.67	1.67	1.67	1.67	0.00	
Replicate 2	0.00	0.00	1.67	0.00	0.00	0.00	
Replicate 3	3.33	0.00	1.67	0.00	0.00	3.33	
Average	1.11	0.56	1.67	0.56	0.56	1.11	
Experiment II							
Replicate 1	0.00	1.67	1.67	1.67	1.67	5.00	0.00
Replicate 2	0.00	5.00	0.00	1.67	1.67	1.67	0.00
Replicate 3	3.33	5.00	0.00	1.67	1.67	5.00	1.67
Average	1.11	3.89	0.56	1.67	1.67	3.89	0.56
Experiment III							
Replicate 1	5.00	3.33	1.67	1.67	0.00	3.33	1.67
Replicate 2	0.00	1.67	0.00	1.67	1.67	0.00	3.33
Replicate 3	0.00	1.67	3.33	1.67	1.67	1.67	1.67
Average	1.67	2.22	1.67	1.67	1.11	1.11	2.22
Average of 3 Experiments	1.30	2.22	1.30	1.30	1.11	2.04	1.39*

* Two Experiments only

Light Dosage Average: 12 Hours 1.61; 24 Hours 1.54

Intensity Average: 15 Foot Candles 1.30; 60 Foot Candles 1.67; 120 Foot Candles 1.76

Effect Upon Mortality

Percent mortality to 10 weeks of age for the various light intensities and light dosages are found in Table 3. The mortality figures are low

ranging from a low of 1.11 percent for the 60 foot candles, 24 hours group, to a high of 2.22 percent for the 60 foot candles, 12 hours group. The combined summary analyses of variance (Table 5) shows none of the differences in mortality between the various groups to be significant.

Table 4. The Effect of Light Intensity and Daily Light Dosage Upon Coefficients of Variability in 10 Weeks Weights (Combined Average of Sexes)

Light Dosage	12 hours			24 hours			Natural Light
Light Intensity (foot candles)	15	60	120	15	60	120	
Experiments and Replicates	Coefficients of Variability						
Experiment I							
Replicate 1	8.17	8.66	12.32	11.17	9.80	7.45	
Replicate 2	7.99	8.14	9.93	11.44	8.66	8.27	
Replicate 3	8.11	8.69	8.04	8.04	6.93	7.41	
Average	8.09	8.50	10.10	10.22	8.46	7.71	
Experiment II							
Replicate 1	7.97	7.91	8.70	9.53	10.96	6.73	8.38
Replicate 2	9.51	11.11	7.87	10.63	9.31	8.62	8.17
Replicate 3	9.28	8.74	9.08	8.05	9.12	8.22	8.33
Average	8.92	9.25	8.55	9.40	9.79	7.86	8.29
Experiment III							
Replicate 1	11.01	10.26	9.55	10.32	7.84	9.91	9.30
Replicate 2	8.92	10.20	8.79	7.70	8.86	8.43	8.73
Replicate 3	8.02	6.68	8.24	8.21	10.86	7.62	8.98
Average	9.32	9.04	8.86	8.74	9.19	8.65	9.01
Average of 3 Experiments	8.78	8.93	9.17	9.45	9.15	8.07	8.65*

* Two experiments only

Light Dosage Average: 12 Hours 8.81; 24 Hours 8.89;
Intensity Average: 15 foot candles 8.89; 60 foot candles 9.04; 120 foot candles 8.62

Coefficients of Variability

Table 4 presents the coefficients of variability based upon the individual body weights of males and females. The lower figures indicate greater uniformity of body weight. The group receiving 120 foot candles with 24 hours of light had the lowest figure (8.07) while the 15 foot candles with 24 hours had the highest figure (9.45). The combined analyses of variance summary of the coefficients of variability (Table 5) shows that none of the differences were significant.

Effect Upon Feather Score

As indicated in the Procedure of the Investigation, each bird was scored at 10 weeks of age on back feathering, with a feather score ranging from one for complete feathering on the back, to four for a completely bare-backed bird. In none of the experiments did a single bare-backed bird show up.

Table 5. Summary of Analysis of Variance of Combined Experiments for 10 Week Body Weights, Feed Conversion, Mortality and Coefficients of Variability Values of Weights of Broilers Reared Under Various Light Intensities and Light Dosages.

		Body Weights	Feed Conversion	Mortality	Coefficients of Variability of Weights
Source of Variation	df	Mean Squares	Mean Squares	Mean Squares	Mean Squares
Replications	6	.0070	.2585*	2.2146	0.0289
Intensity	6	.0060	.0015	.3603	0.4254
Dosage	3	.0001	.0024	.0166	0.0200
Intensity x Dosage	6	.0011	.0007	1.5567	1.2711
Error	30	.0062	.0027	3.3214	2.5365

* Statistically significant at the .01 level

Part II — Light Intensity, Feed Form, and Floor Space Allotment

Since in Part I, neither light intensity nor light dosage, within the ranges employed, had any influence on feather picking, the two extremes of light intensity were combined with two forms of feed and two floor space allotments. The feed forms were mash and pellets, and the floor space allotments were 1 square foot and $\frac{2}{3}$ square foot per bird.

Table 6. The Effect of Feed Form, Space Allotment, and Light Intensity Upon Body Weight of Combined sexes at 10 Weeks of Age.

Light Intensity	15 foot candles				120 foot candles			
Feed Form	Mash		Pellets		Mash		Pellets	
Floor Space	1 sq. ft	$\frac{2}{3}$ sq. ft	1 sq. ft	$\frac{2}{3}$ sq. ft	1 sq. ft	$\frac{2}{3}$ sq. ft	1 sq. ft	$\frac{2}{3}$ sq. ft
Experiments and Replicates	Average Weight in Pounds							
Experiment IV								
Replicate 1	3.40	3.34	3.48	3.44	3.31	3.16	3.43	3.41
Replicate 2	3.26	3.23	3.41	3.46	3.17	3.09	3.27	3.33
Average	3.33	3.29	3.45	3.45	3.24	3.13	3.35	3.37
Experiment V								
Replicate 1	3.21	3.26	3.40	3.46	3.27	3.11	3.48	3.23
Replicate 2	3.34	3.26	3.27	3.48	3.28	3.18	3.43	3.38
Average	3.28	3.26	3.34	3.47	3.28	3.15	3.46	3.31
Experiment VI								
Replicate 1	3.50	3.42	3.72	3.54	3.48	3.49	3.71	3.53
Replicate 2	3.45	3.46	3.81	3.55	3.37	3.44	3.66	3.49
Average	3.48	3.44	3.77	3.55	3.42	3.47	3.69	3.51
Average of 3 Experiments	3.36	3.33	3.52	3.49	3.31	3.25	3.50	3.40

Intensity Average: 15 Foot Candles 3.42; 120 Foot Candles 3.36

Feed Form Average: Mash 3.31; Pellets 3.47

Floor Space Average: 1 Sq. Ft. 3.42; $\frac{2}{3}$ Sq. Ft. 3.36

Effect Upon Body Weight

Table 6 presents the average, ten week weight of combined sexes of birds reared under two feed forms, two space allotments and two light intensities. The heaviest birds were the group on 15 foot candles, fed pellets, and allotted 1 square foot of floor space per bird with an average weight of 3.52 pounds. The lighest group was the 120 foot candles, mash and ⅔ square foot group with an average weight of 3.25 pounds. The 15 foot candle groups were heavier than their corresponding 120 foot candles groups. The same was true for the pellet-fed groups compared with their corresponding mash-fed groups and for the 1 square foot of floor space compared with the ⅔ square feet of floor space groups. The differences were large among experiments, between light intensities, and between rations (feed form). However, the combined analysis of variance summary for the three experiments (Table II) indicates that none of the differences were significant, in terms of large interacting or inconsistancies, among combinations of intensities, space, and trials, and among combinations of ration, space, and trials.

Table 7. The Effect of Feed Form, Space Allotment, and Light Intensity Upon Feed Conversion to 10 Weeks of Age.

Light Intensity	15 foot candles				120 foot candles			
Feed Form	Mash		Pellets		Mash		Pellets	
Floor Space	1 sq. ft	⅔ sq. ft	1 sq. ft	⅔ sq. ft	1 sq. ft	⅔ sq. ft	1 sq. ft	⅔ sq. ft
Experiments and Replicates	Pounds of Feed Required to Produce a Pound of Gain							
Experiment IV								
Replicate 1	2.55	2.37	2.36	2.36	2.40	2.53	2.61	2.46
Replicate 2	2.52	2.49	2.43	2.41	2.42	2.47	2.44	2.38
Average	2.53	2.44	2.39	2.39	2.41	2.50	2.53	2.42
Experiment V								
Replicate 1	2.64	2.70	2.54	2.54	2.70	2.59	2.49	2.31
Replicate 2	2.55	2.64	2.58	2.50	2.56	2.70	2.43	2.63
Average	2.60	2.67	2.56	2.52	2.63	2.65	2.46	2.47
Experiment VI								
Replicate 1	2.43	2.56	2.46	2.43	2.53	2.52	2.54	2.49
Replicate 2	2.40	2.46	2.36	2.62	2.50	2.51	2.39	2.48
Average	2.42	2.51	2.41	2.53	2.52	2.52	2.47	2.49
Average of 3 Experiments	2.52	2.54	2.45	2.48	2.52	2.56	2.49	2.46

Intensity Average: 15 Foot Candles 2.50; 120 Foot Candles 2.50
Feed Form Average: Mash 2.53; Pellets 2.47
Floor Space Average: 1 Sq. Ft. 2.49; ⅔ Sq. Ft. 2.51

Effect Upon Feed Conversion

Table 7 presents the effect of feed form, floor space allotment, and light intensity upon feed conversion to 10 weeks of age. The best feed conversion of 2.45 pounds of feed required to produce a pound of gain was ob-

tained in the group on 15 foot candles, pelleted feed, and 1 square foot of floor space per bird. The poorest group with a conversion of 2.56 was the 120 foot candles, mash, and $\frac{2}{3}$ square foot group. There were no differences between the corresponding 15 and 120 foot candles groups. Small differences appeared between the corresponding mash and pellet groups and the 1 square foot and $\frac{2}{3}$ square foot groups. The analysis of variance for the combined experiments (Table II) shows that ration had a significant influence on feed conversion. The differences among experiments were highly significant.

Table 8. The Effect of Feed Form, Space Allotment and Light Intensity Upon Coefficient of Variability in Body Weight of Combined Sexes at 10 Weeks of Age.

Light Intensity	15 foot candles				120 foot candles			
Feed Form	Mash		Pellets		Mash		Pellets	
Floor Space	1 sq. ft	$\frac{2}{3}$ sq. ft	1 sq. ft	$\frac{2}{3}$ sq. ft	1 sq. ft	$\frac{2}{3}$ sq. ft	1 sq. ft	$\frac{2}{3}$ sq. ft
Experiments and Replicates	Coefficients of Variability							
Experiment IV								
Replicate 1	8.82	8.81	9.24	9.28	9.25	12.40	9.25	9.75
Replicate 2	8.79	8.45	8.47	7.54	9.04	11.35	8.02	8.62
Average	8.81	8.63	8.86	8.41	9.15	11.88	8.64	9.19
Experiment V								
Replicate 1	10.83	8.66	9.13	8.87	7.49	9.26	8.62	9.02
Replicate 2	8.67	8.24	13.08	7.78	8.72	7.10	7.41	8.53
Average	9.75	8.45	11.11	8.33	8.11	8.18	8.02	8.78
Experiment VI								
Replicate 1	7.44	8.43	9.50	8.63	9.01	8.15	9.43	7.98
Replicate 2	8.18	7.17	7.57	9.66	8.03	9.39	7.83	10.33
Average	7.81	7.80	8.54	9.15	8.52	8.77	8.63	9.16
Average of 3 Experiments	8.79	8.29	9.50	8.63	8.59	9.61	8.43	9.04

Intensity Average: 15 Foot Candles 8.80; 120 Foot Candles 8.92
Feed Form Average: Mash 8.82; Pellets 8.90
Floor Space Average: 1 Sq. Ft. 8.83; $\frac{2}{3}$ Sq. Ft. 8.89

Coefficients of Variability

Table 8 presents the coefficients of variability based upon the individual body weight of males and females. The most uniform group was the 15 foot candles, mash, $\frac{2}{3}$ square foot groups with a coefficient of variability of 8.29. The poorest was the 120 foot candles, mash, $\frac{2}{3}$ square foot group with a value of 9.61.

The analysis of variance of the combined experiments (Table II) indicates that in no instance was there a significant difference in individual variation in body weight.

Table 9. The Effect of Feed Form, Space Allotment, and Light Intensity Upon Per Cent Mortality to 10 Weeks of Age.

Light Intensity	15 foot candles				120 foot candles			
Feed Form	Mash		Pellets		Mash		Pellets	
Floor Space	1 sq. ft	⅔ sq. ft	1 sq. ft	⅔ sq. ft	1 sq. ft	⅔ sq. ft	1 sq. ft	⅔ sq. ft
Experiments and Replicates	Per Cent Mortality							
Experiment IV								
Replicate 1	3.33	0.00	11.67	3.33	3.33	0.00	0.00	1.11
Replicate 2	1.67	4.44	1.67	7.78	1.67	3.33	1.67	4.44
Average	2.50	2.22	6.67	5.56	2.50	1.67	0.84	2.78
Experiment V								
Replicate 1	3.33	2.22	1.67	2.22	6.67	1.11	1.67	0.00
Replicate 2	1.67	1.11	1.67	1.11	1.67	2.22	0.00	3.33
Average	2.50	1.67	1.67	1.67	4.17	1.67	0.84	1.67
Experiment VI								
Replicate 1	0.00	2.22	1.67	1.11	3.33	1.11	3.33	0.00
Replicate 2	0.00	1.11	0.00	0.00	0.00	3.33	0.00	0.00
Average	0.00	1.67	0.84	0.56	1.67	2.22	1.67	0.00
Average of 3 Experiments	1.67	1.85	3.06	2.60	2.78	1.85	1.12	1.48

Intensity Average: 15 Foot Candles. 2.29; 120 Foot Candles.1.81
Feed Form Average: Mash, 2.04; Pellets, 2.06
Floor Space Average: 1 Sq. Ft., 2.15; ⅔ Sq. Ft., 1.94

Effect Upon Mortality

Table 9 presents the effect of feed form, space allotment, and light intensity upon percent mortality to ten weeks of age. The lowest mortality percentage of 1.12 was in the 120 foot candles, pellets, and 1 square foot group; the highest in the 15 foot candles, pellets, and 1 square foot group with 3.06 percent. The analysis of variance of the combined three experiments (Table II) indicates that none of the differences in mortality were significant.

Effect Upon Feather Score

Average feather score resulting from the effect of feed form, space allotment, and light intensity are shown for males in Table 10. The score for males only are shown because in most cases the females did not show any tendency toward bare-backs. It should be remembered that a score of 1.0 indicates a completely feathered-back. The best average feather score of 1.03 was found in both the 15 and the 120 foot candles, mash, and 1 square foot per bird groups. The two poorest were the 15 foot candles, pellets, ⅔ square foot group and the 120 foot candles, pellets, ⅔ square foot group, with scores of 1.62 and 1.84 respectively.

The analysis of variance for the combined three experiments (Table II) shows that ration had a highly significant, and space allotment a significant effect on feather picking in males.

Table 10. The Effect of Feed Form, Space Allotment, and Light Intensity Upon Feather Picking in Male Broilers (Based on Feather Score)

Light Intensity	15 foot candles				120 foot candles			
Feed Form	Mash		Pellets		Mash		Pellets	
Floor Space	1 sq. ft	$\frac{2}{3}$ sq. ft	1 sq. ft	$\frac{2}{3}$ sq. ft	1 sq. ft	$\frac{2}{3}$ sq. ft	1 sq. ft	$\frac{2}{3}$ sq. ft
Experiments and Replicates	Average Feather Score							
Experiment IV								
Replicate 1	1.06	1.26	1.07	1.16	1.00	1.19	1.47	1.66
Replicate 2	1.00	1.16	1.32	1.16	1.00	1.00	1.16	1.05
Average	1.03	1.21	1.20	1.16	1.00	1.19	1.32	1.36
Experiment V								
Replicate 1	1.03	1.15	1.10	2.13	1.15	1.05	1.22	1.93
Replicate 2	1.00	1.05	1.97	1.16	1.00	1.24	1.07	2.35
Average	1.02	1.10	1.54	1.65	1.08	1.15	1.15	2.14
Experiment VI								
Replicate 1	1.00	1.00	1.83	1.77	1.00	1.09	1.20	2.22
Replicate 2	1.05	1.02	1.00	2.34	1.00	1.27	1.36	1.80
Average	1.03	1.01	1.42	2.06	1.00	1.18	1.28	2.01
Average of 3 Experiments	1.03	1.11	1.39	1.62	1.03	1.17	1.25	1.84

Intensity Average: 15 Foot Candles 1.28; 120 Foot Candles 1.31
Feed Form Average: Mash 1.07; Pellets 1.52
Floor Space Average: 1 Sq. Ft. 1.17; $\frac{2}{3}$ Sq. Ft. 1.42

TABLE 11. Summary of Analyses of Variance of Combined Experiments for 10 Week Body Weights, Feed Conversion, Mortality, Coefficients of Variability Values of Body Weights and Feather Scores of Broilers Reared Under Various Light Intensities, Feed Form, and Floor Spaces Allotment.

Source of Variation	df	Body Weights Mean Squares	Feed Conversion Mean Squares	Coefficients of Variability of Body Weights Mean Squares	Mortality Mean Squares	Feather Scores Mean Squares
Experiments	2	.2563	.0610*	1.6792	16.2879	.1964
Replicates Within Experiments	3	.0131*	.0015	1.0038	2.5402	.0233
Treatments	7					
Intensity	1	.0438	.0007	.1564	2.8422	.0099
Ration	1	.3153	.0469†	.0721	.0070	2.3986*
Space	1	.0391	.0021	.0520	.5334	.7880†
I R	1	.0003	.0001	2.3674	13.0417	.0015
I S	1	.0094	.0009	6.7350	.0574	.1093
R S	1	.0006	.0027	.4602	.3137	.2961
I R S	1	.0011	.0027	.0007	2.8422	.0760
Treatments by Experiments	14	.0088*	.0081	1.9574	4.2296	.0946
I E	2	.0064	.0055	5.0561†	9.9553	.0044
R E	2	.0006	.0152	2.5823	8.9809	.2370
I R E	2	.0023	.0103	0.3397	2.8569	.0389
S E	2	.0050	.0082	2.4111	.5440	.1088
I S E	2	.0175*	.0054	1.5573	1.6179	.0502
R S E	2	.0261*	.0019	0.6994	4.6505	.1554
I R S E	2	.0041	.0107	1.0565	1.0018	.0679
Replicates by Treatments Within Experiments	21	.0027	.0068	1.1596	5.5343	.0871

* Statistically Significant at the .01 level

† Statistically Significant at the .05 level

I = Intensity. E = Experiment. R = Ration. S = Space

DISCUSSION

The results in Part 1 indicated that when feed was provided in mash form and one square foot of floor space was provided per bird, light intensities up to 120 foot candles were not factors in initiating feather picking.

With respect to body weight, the evidence presented indicated that whether the day was 12 hours or 24 hours long, the final body weight of broiler was not affected. Many broiler growers utilize all-night lights and this experiment indicated that this practice is not warranted in respect to growth.

Birds exposed to only 15 foot candles weighed more than those exposed to 60 or 120 foot candles, but the differences were not significant. Hammond and Titus (1941) mentioned that chicks in an environment of low light intensity did not readily learn to eat, which in turn influenced their weight. It can probably be assumed, although their paper did not specify, that they were dealing with an intensity lower than 15 foot candles. This intensity proved ample, in this experiment, to enable the birds to eat. In regards to the other characteristics of feed conversion, mortality rate, and uniformity of body weight, neither light intensity nor light dosage had any significant effect upon the results.

The results in Part 2 indicated that when males were fed pelleted feed, the increase in feather picking was statistically highly significant. When males were crowded with only $\frac{2}{3}$ square foot of floor space, the increase in feather picking likewise was statistically significant. It should be noted that no debeaking was practiced in the experiment. Based on industry experience, debeaking would probably have permitted the use of pelleted feed and crowding without increased feather picking. As in Part 1, light intensity studied by itself, without the stress of pelleted feed or crowding, produced only very minor feather picking. It was apparent that feed form and floor space allotment were critical factors in producing feather picking. High intensity (120 foot candles) combined with pelleted feed and crowding ($\frac{2}{3}$ square foot per bird) resulted in the highest rate of feather picking.

Heavier body weight was obtained in the 15 foot candles group than in the corresponding groups with 120 foot candles, although the differences were not consistent for all combinations of space and trials. Body weight was heavier for the pellet-fed than for the mash-fed groups, though not consistently so. The superior feed conversion resulting from pellet compared to mash feeding was statistically significant. Floor space allotments studied failed to exert any significant effect upon either body weight or feed conversion.

Neither feed form, space allotment, nor light intensity had any significant effect upon percent mortality or upon uniformity of body weight.

SUMMARY AND CONCLUSIONS

One of the problems which has plagued the poultry industry throughout the years has been that of cannibalism. Broiler growers are constantly faced with serious losses in income due to the lower price they receive when bare-backed broilers are marketed. Theories have been advanced by some investigators that light intensity might play an important role in cannibalism among chickens as well as upon other characteristics.

Two series of experiments were conducted at the University of New Hampshire. In the first series, the effect of light intensity and daily light dosage on broilers was investigated. Measurements made were feather picking on the back, body weight, feed conversion, mortality rate, and uniformity of body weight. Reflector-type flood light bulbs were used to provide light intensities of 15, 60, and 120 foot candles, measured at the height of the feeder, and the daily light dosages were 12 and 24 hours.

There was no evidence of feather picking in this series of experiments. Neither was there any significant difference among groups with respect to body weight, feed conversion, mortality rate, and uniformity of body weight.

Based on the results of the first series of experiments a second series was established in which the two extremes of light intensities, 15 and 120 foot candles, were compared and combined with two feed forms, mash and pellets, and two floor space allotments, 1 square foot and $\frac{2}{3}$ square foot. Once again it was demonstrated that light intensity itself has no effect upon feather picking under conditions of this experiment, but birds fed pellets or allowed $\frac{2}{3}$ square foot per bird tended toward increased feather picking. The pellet-fed groups had higher body weight and significantly superior feed conversion compared to the mash-fed groups. Body weights from the lower light intensity groups were heavier than those from the higher light intensity groups.

Within the limits of the experiments reported here the following conclusions are drawn:

1. When broilers were fed feed in mash form and allowed 1 square foot of floor space per bird, neither daily light dosages of 12 or 24 hours, nor light intensities of 15, 60 and 120 foot candles had any significant effect in inducing cannibalism as expressed by feather picking on the back.

2. The light intensities and light dosages mentioned above had no effect upon body weight, feed conversion, mortality rate, or uniformity of body weight.

3. Use of either pelleted feed or a floor space allotment of $\frac{2}{3}$ square foot per bird resulted in a significant increase in feather picking.

4. In the second series of experiments in contrast to results in the first series, the body weights of the lower light intensity (15 foot candles) groups were heavier than those of the higher light intensity (120 foot candles) groups, but the difference was not statistically significant.

5. Use of pelleted feed resulted in heavier body weight and superior feed conversion, though the difference in body weight was not statistically significant.

6. Light intensities, feed forms and/or floor space allotments had no significant effect upon mortality rate or uniformity of body weight.

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